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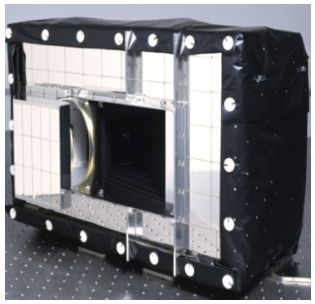
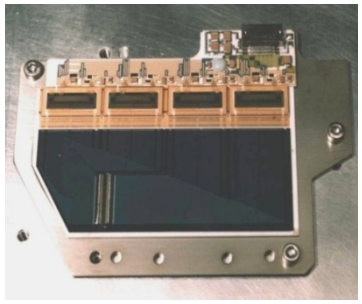
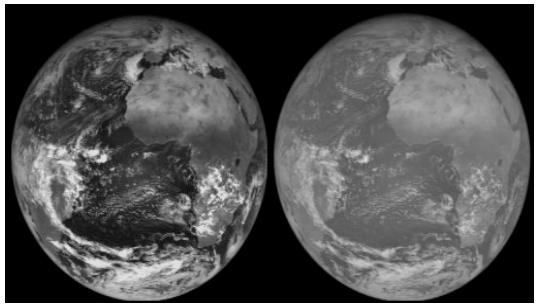
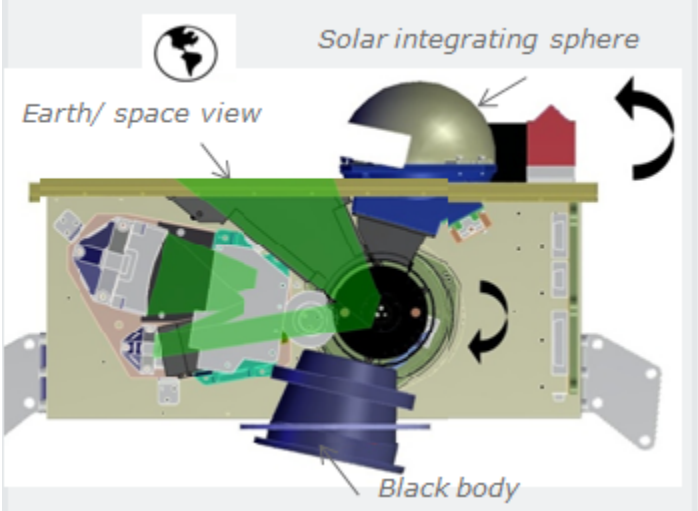
Geostationary Earth Radiation Budget GERB unit level spectral response data




Jacqui Russell, (GERB project scientist)

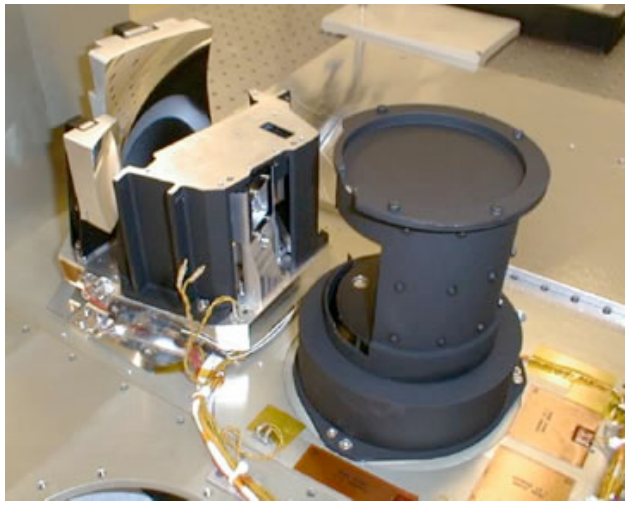
How GERB obtains each scan

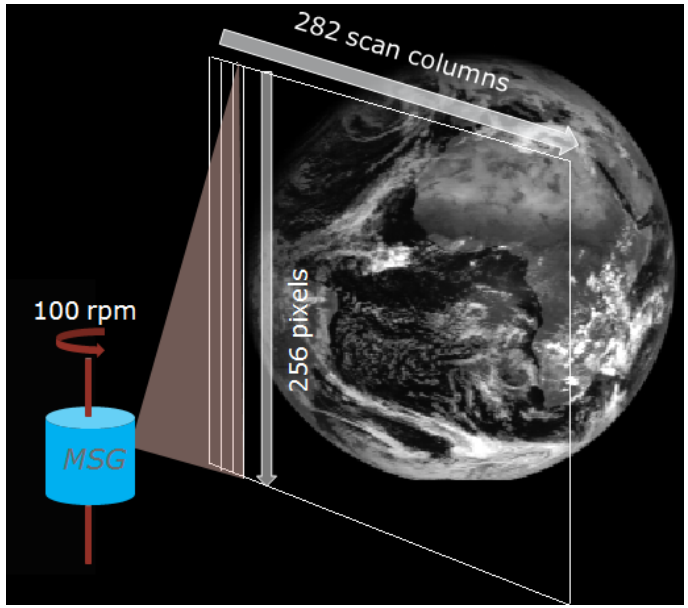


Plan view: scan mirror, telescope, BB(LW cal), integrating sphere (SW cal).

Telescope consists of 5 UV enhanced silver coated mirrors

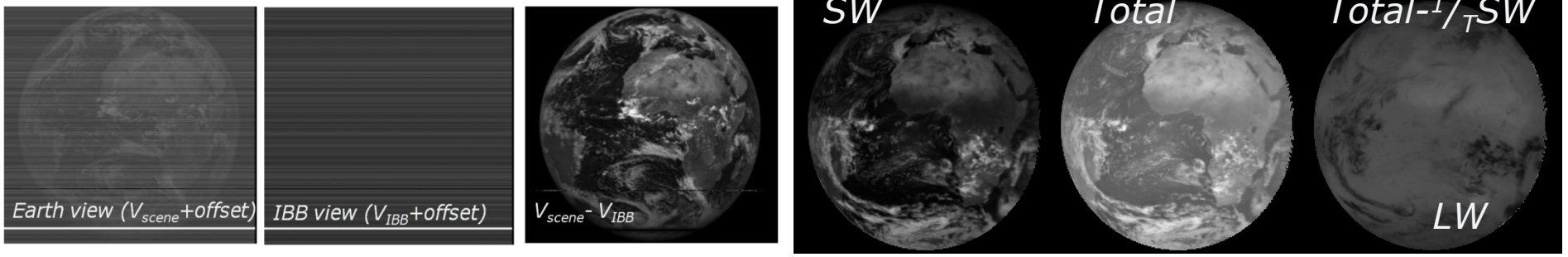
Scan mirror and telescope





A detector array oriented roughly N-S wrt to Earth builds up scan of the Earth as a series of 282 columns. A column is obtained every rotation of the MSG satellite (0.6s), with data acquisition time of 40ms.

From counts to radiance and flux



Internal black body is used to remove offsets and calibrate the counts to SW and Total filtered radiances. This requires **ground calibration parameters for the IBB and the gain ratio (B)**

LW is obtained by subtracted of SW from TOTAL, allowing for effect of quartz filter, requires **ground calibration info regard quartz filter transmission**.

At a later stage the resulting filtered radiances are unfiltered**, requiring knowledge of the instrument spectral response**

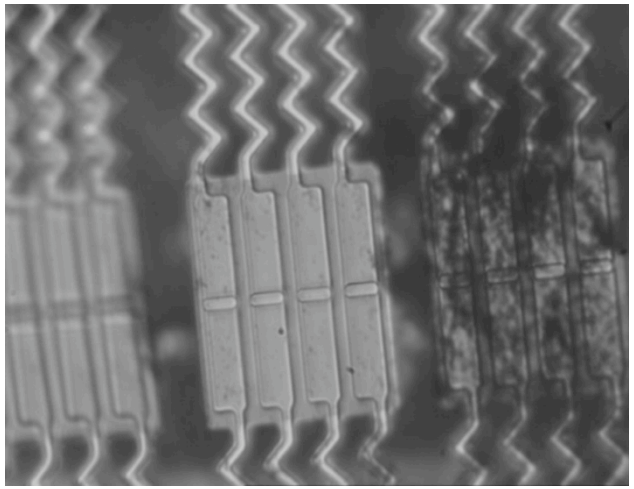
$$\text{Gain (TOT)} = \frac{\text{V(BB)} - \text{V(space)}}{\text{BB radiance}}$$

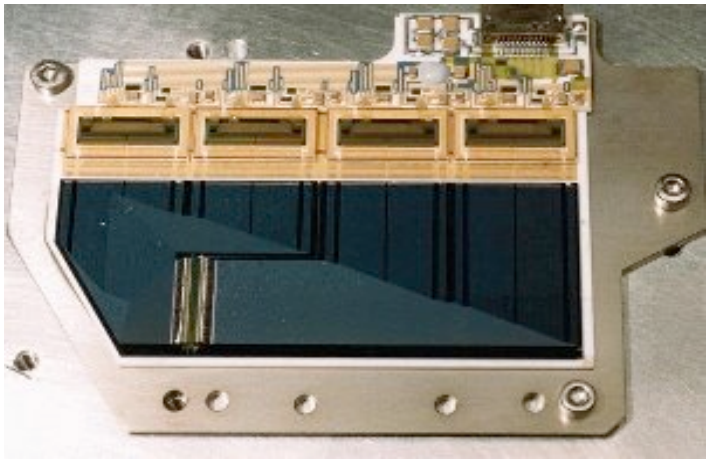
$$\text{Gain (SW)} = B\text{x}\text{Gain (TOT)}$$

$$\text{Scene radiance} = \frac{\text{V(Scene)} - \text{V(BB)}}{\text{Gain}} + \text{BB radiance}$$

GERB pixels

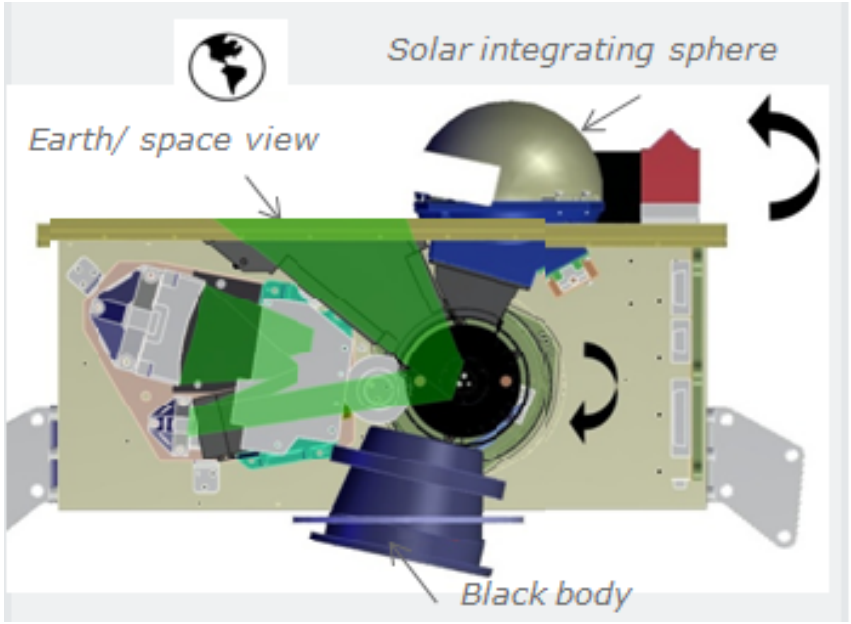
- *GERB pixels are thermo-electric detectors approximately 54 x 45 μm. Time constant 4-6ms.*
- *The detectors are vacuum coated with a gold black to provide response across the full IR.*
- *The detectors must have a low thermal inertia to respond as quickly as possible to short scene observations due to MSG rotation.*
- *The measurement recorded is an extrapolated steady state based on measured pixel performance.*





GERB mirrors

- *GERB instrument used 5 mirrors which have a special Denton UV enhanced mirrors (same as CERES mirrors).*
- *In addition to the primary de-spin / scan mirror, there are 3 mirrors plus a fold mirror which minimises the effect of polarisation*
- *De-spin mirror hold image of the Earth stationary in the FOV for a 40ms integration time each 0.6s rotation of the satellite. Also enables internal views of the black body and SW integrating sphere for calibration*



Instrument: ground cal – unit level

256 detectors:

- Pixel time constants and spectral response between 0.34 and 20μm is measured for each of the 256 detectors at LU.
- Witness sample black measurements (gold black coated glass 2.5-55μm), used supplement this information for the longer wavelengths

Mirrors:

Flat samples from the same coating batch as each of the mirrors are measured at a range of angle of incidences both linearly polarizations from 0.3-50μm, these are used as input into ray tracing model at RAL to calculate telescope response for each pixel

Filter:

Measurements from 0.2 to 5μm and from 50 to 150μm made on each filter at NPL are supplemented with manufacturer data

Accuracy of RELATIVE spectral response of importance in the above measurements as absolute level provided at system level via ground cal

Instrument: ground cal – system level

Broad band response to determine absolute calibration and internal black body calibration at Imperial sing NPL provided SW and IR sources traceable to international standards

System level spot checks on the instrument spectral response using narrow band filters to compare against that determined from unit level measurements

Variable temperature black bodies used to provide information on the structure of the response at the longer wavelengths.

System level measurements of instrument point spread function and linearlity

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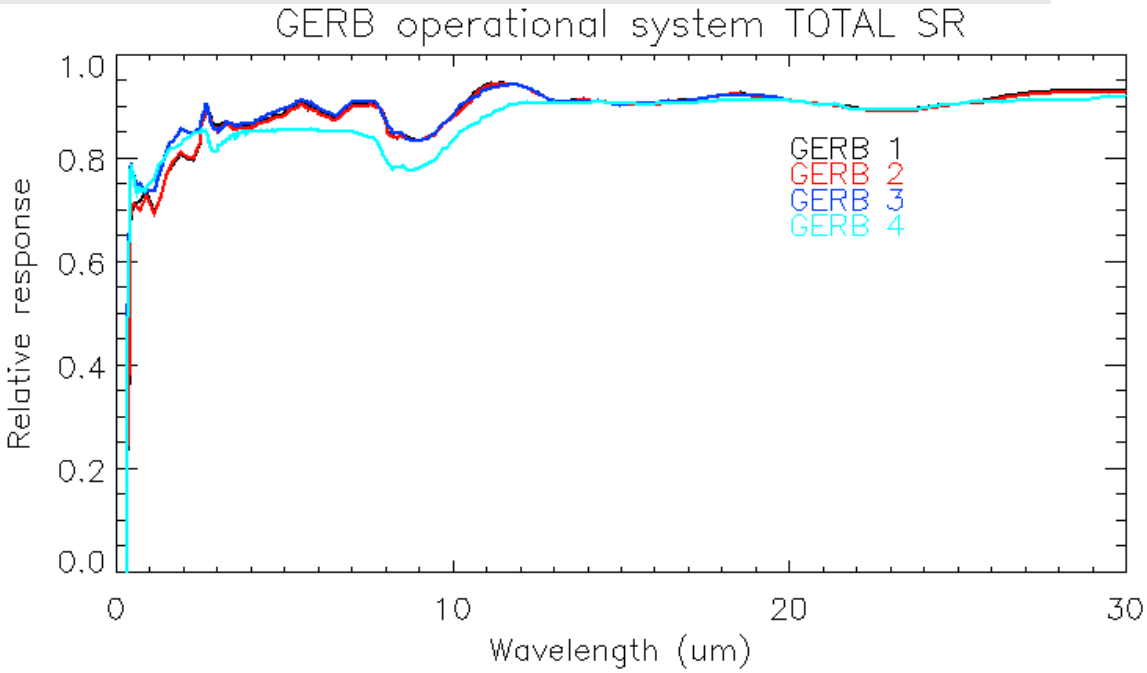
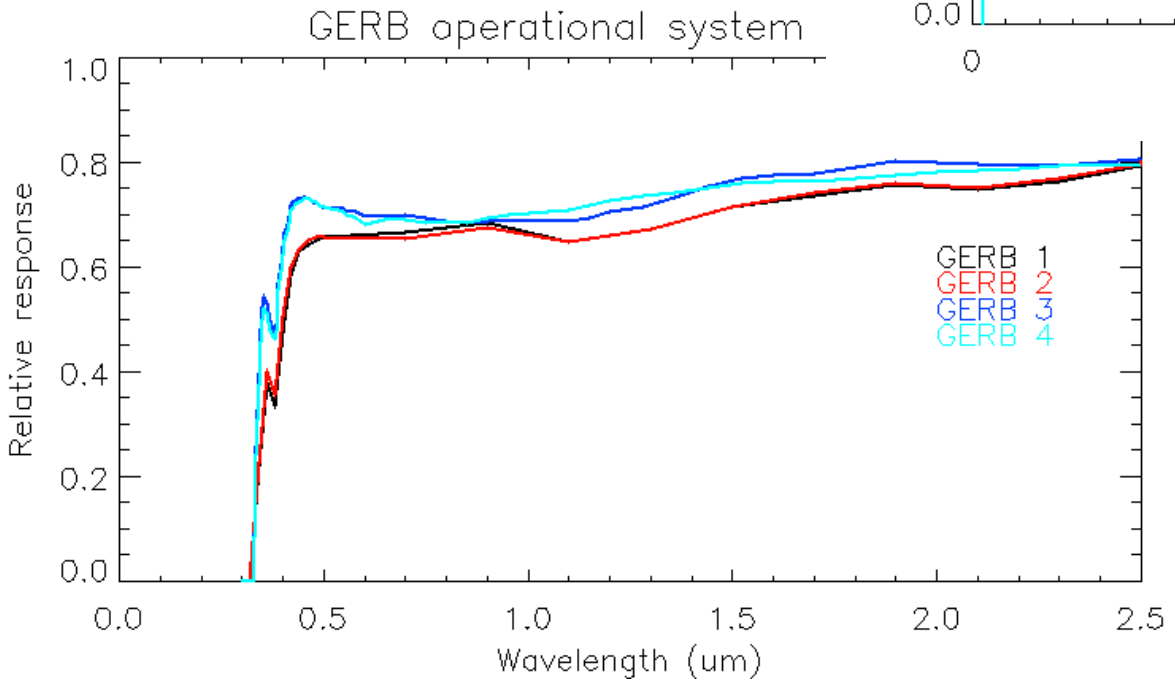
Observations
Instrument
SR: all components

Combined response

4 GERB instruments, utilizing different mirror batches.

Detector response based on the same measurements for GERB 1, 2 & 3, new measurements for the GERB 4 detector

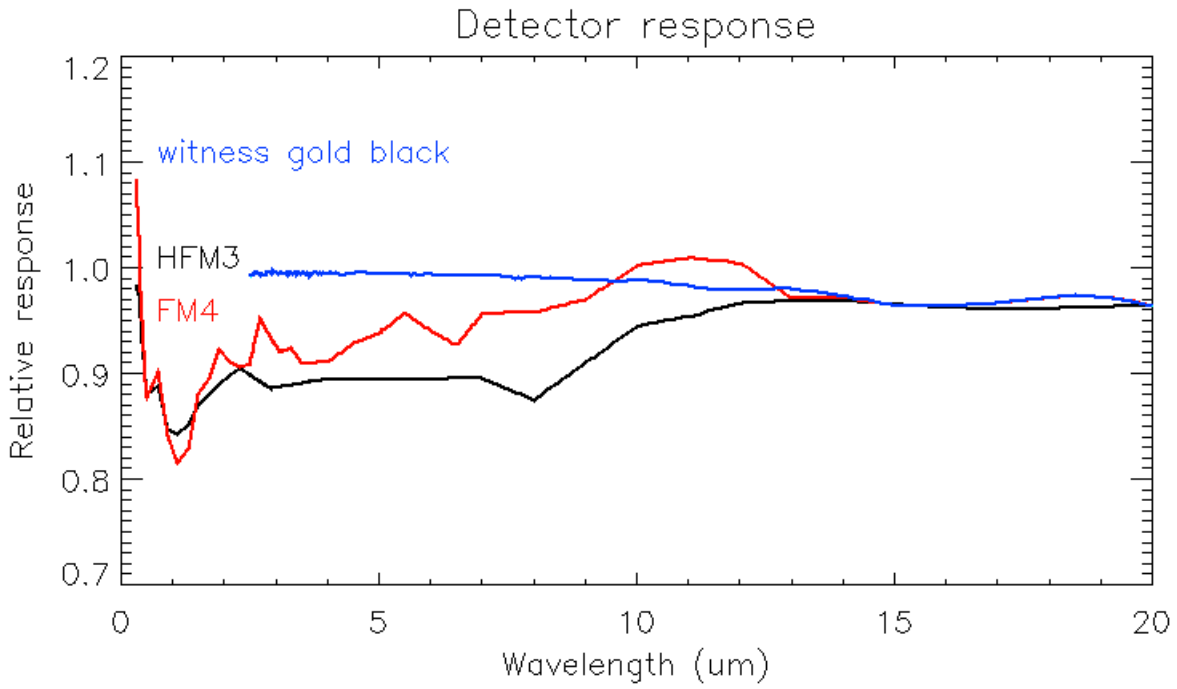


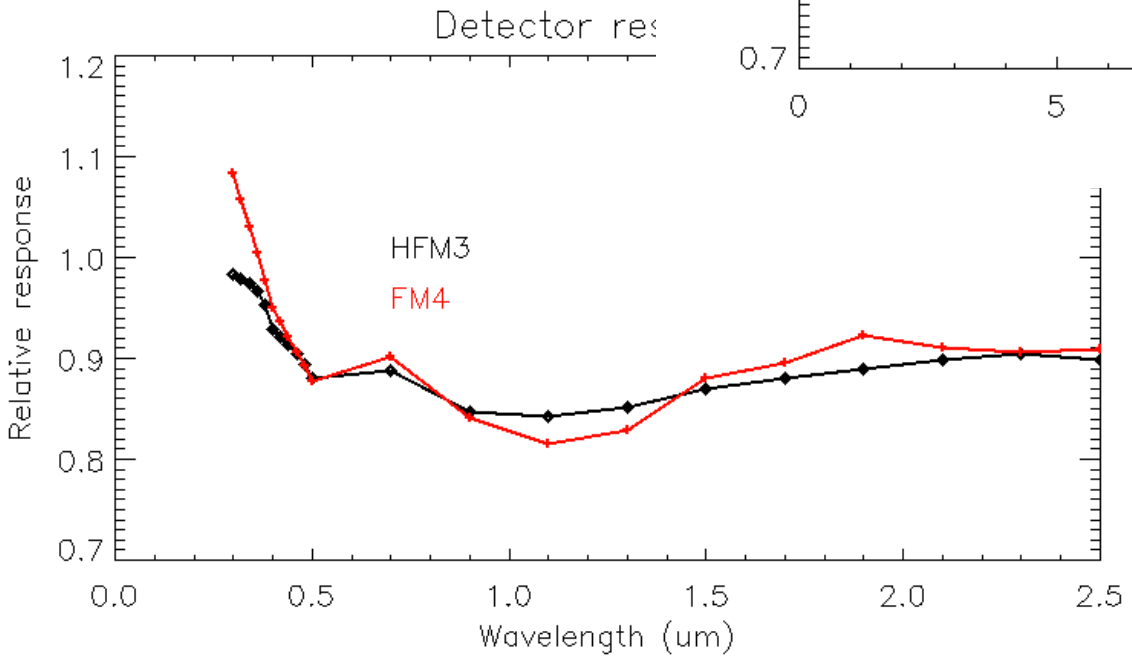


Full response provided to 500μm. Based on mirror and filter measurements out to 150μm, detector data to 20 + witness sample black data to 55μm.

Detector SR measurements

FM4 are the measurements made on the GERB 2 detector. Some corrections required post measurement on these due to issues uncovered post launch.





HFM3 is the GERB 4 detector, same batch of detectors as all other GERBs. Measurements use new technique, improved spectral response and accuracy

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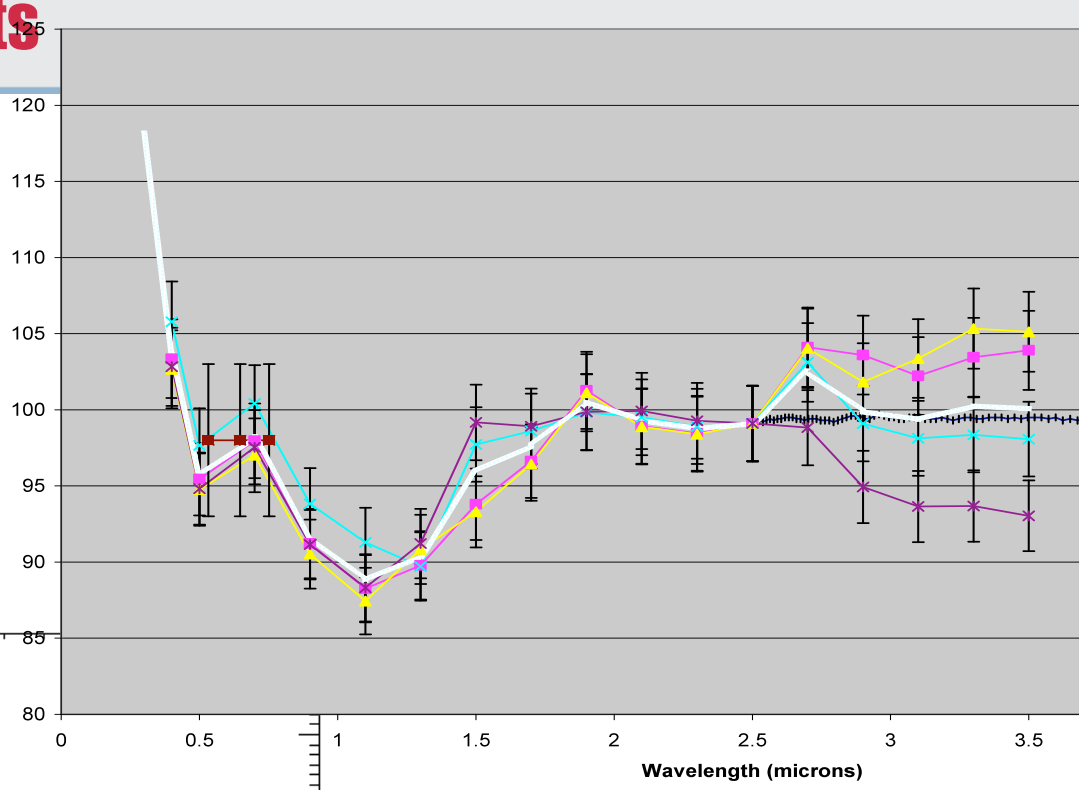

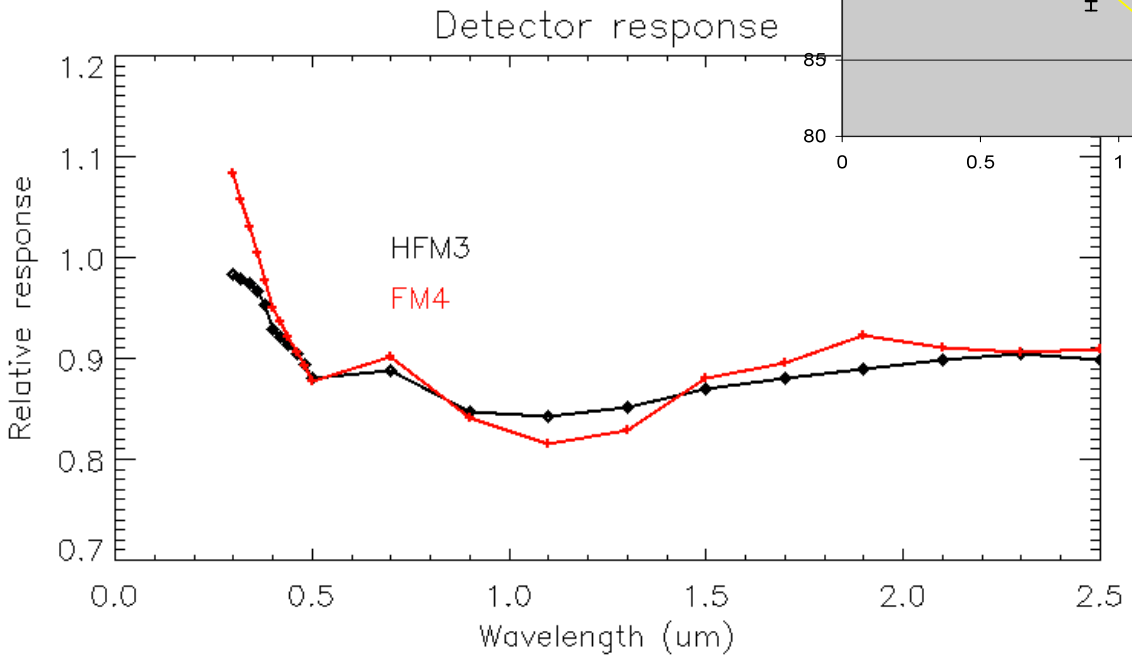

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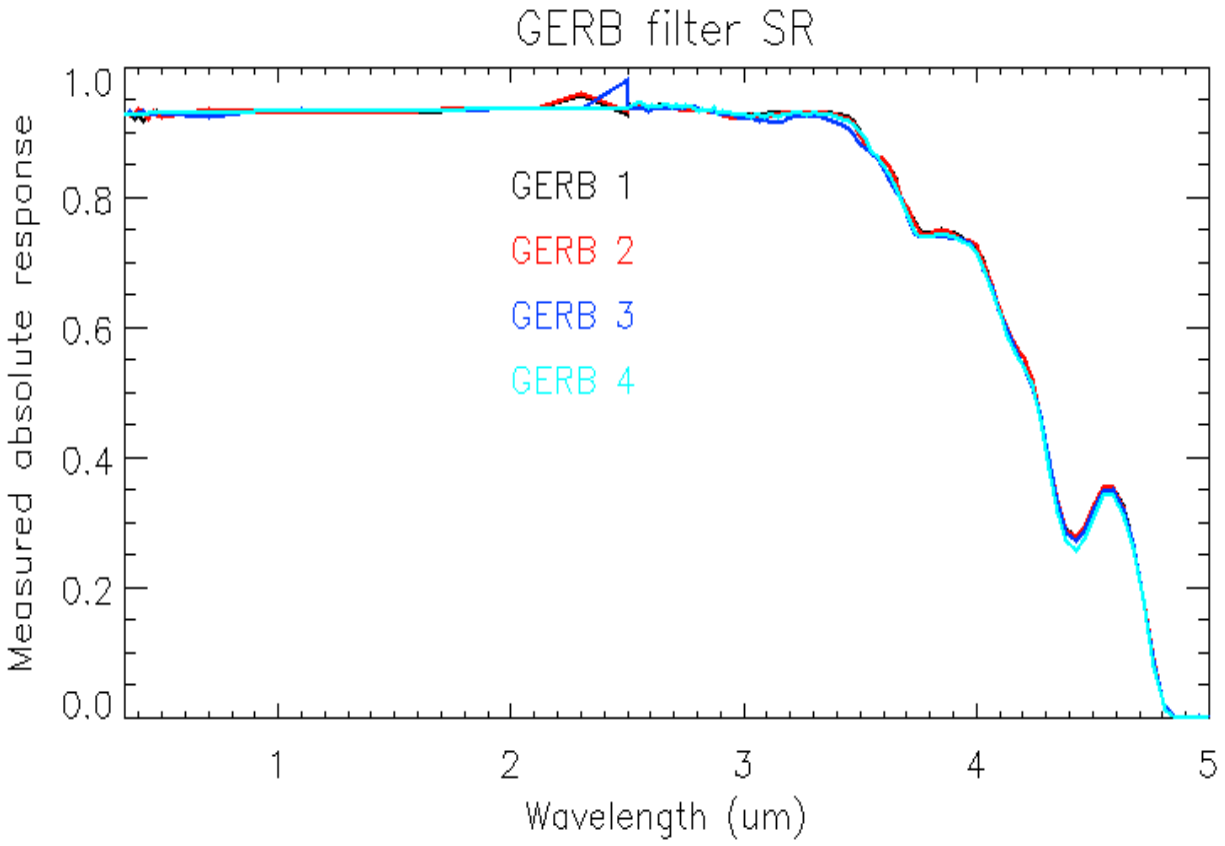
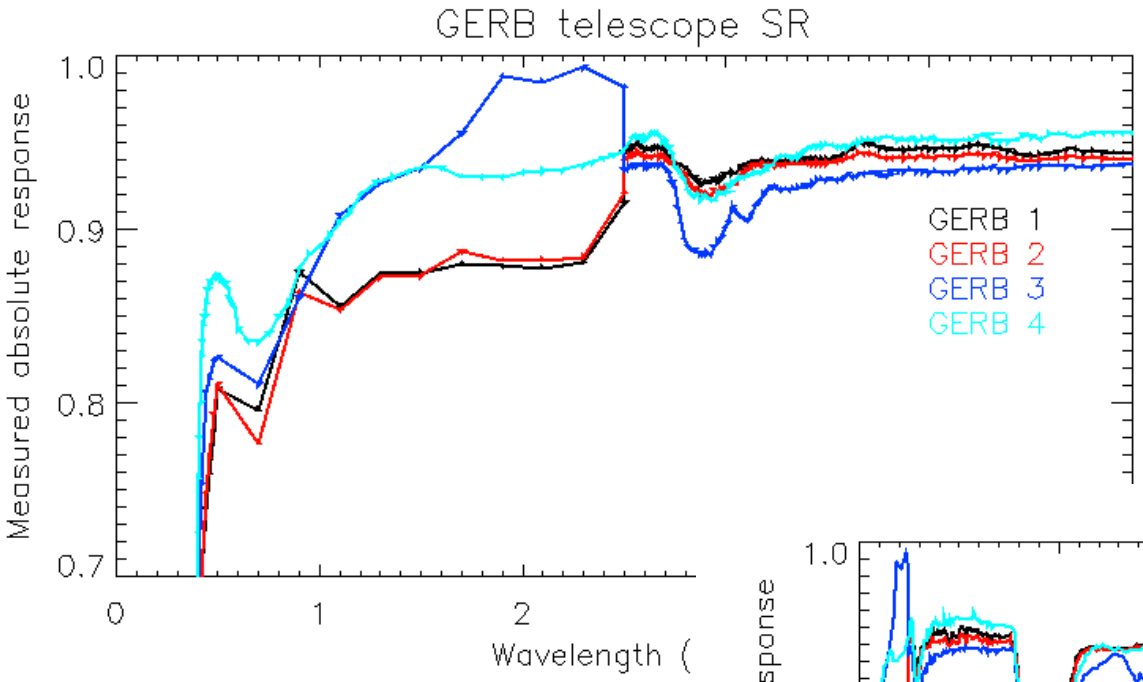
Filter SR measurements

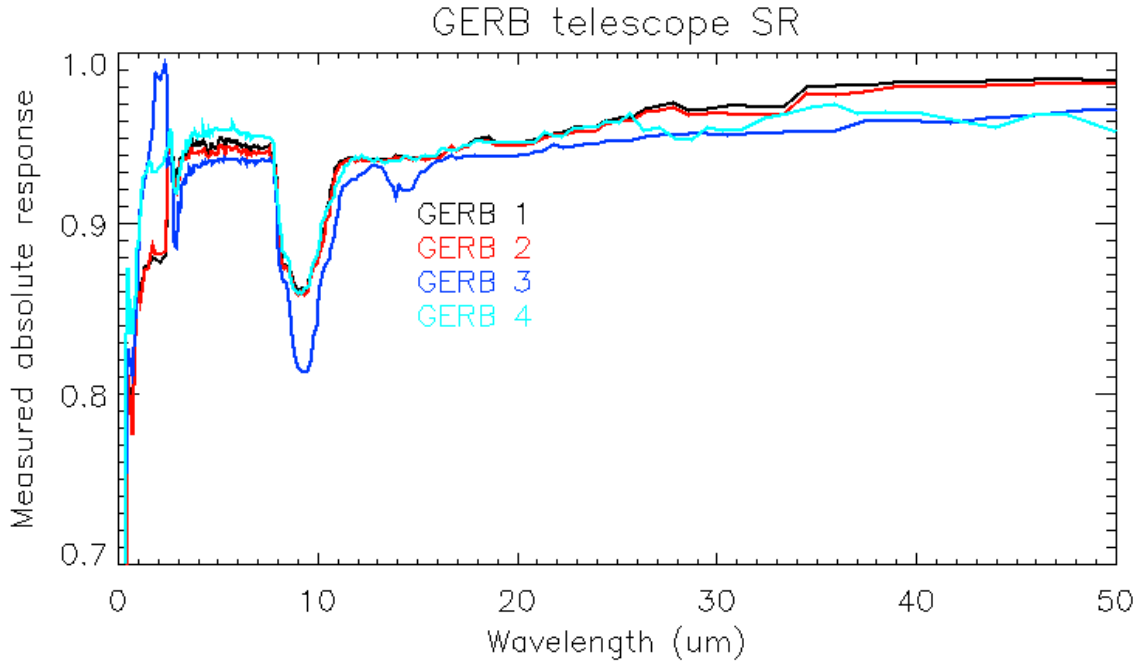


SW / TOTAL telescope, note some interpolation effects in this plot due to different spectral response of the two channels

Mirror SR measurements



Flat witness samples from same coating batch measured and ray tracing used to determined combined response for GERB mirrors fore each pixel



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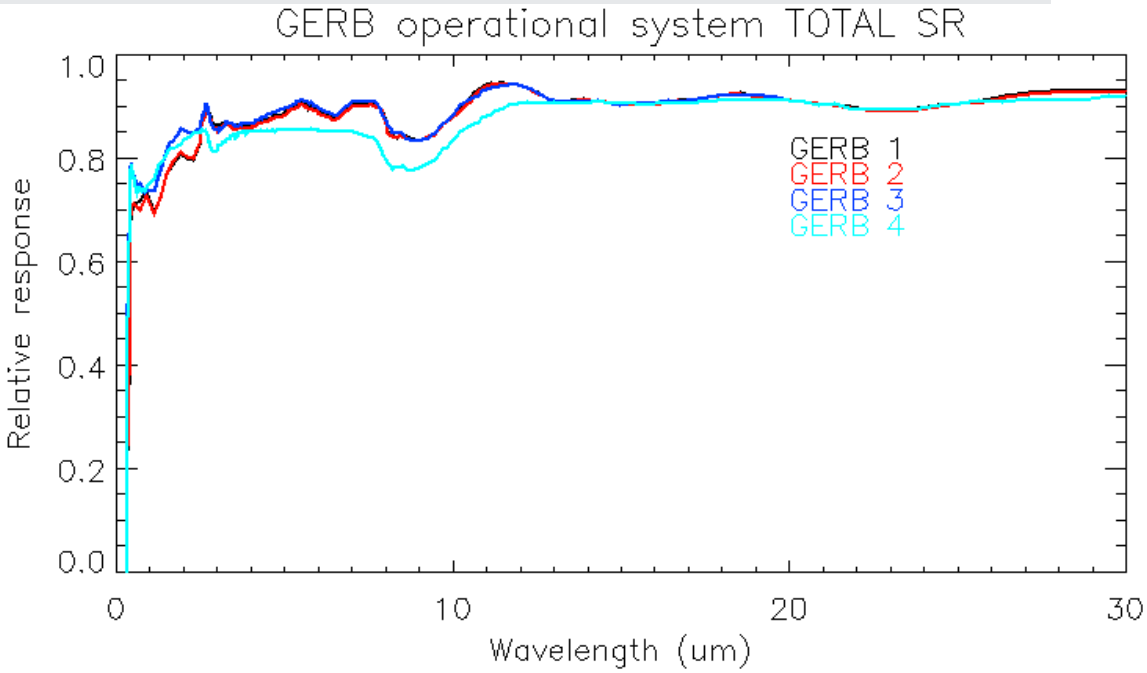

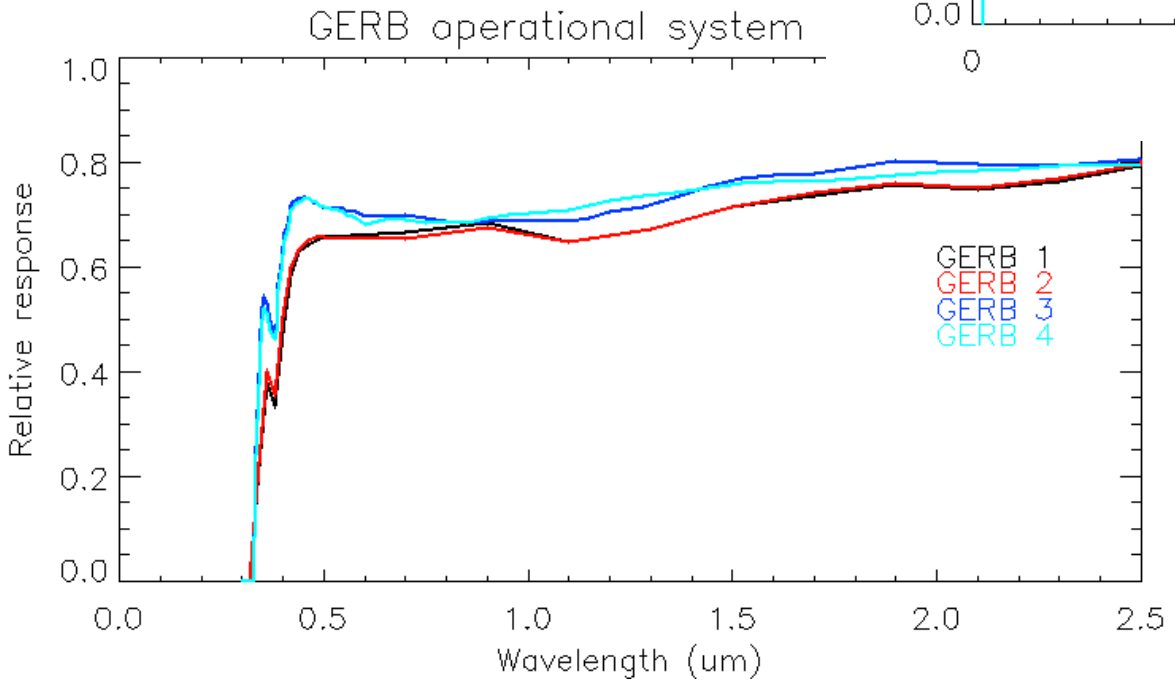

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Summary

- GERB 4 unit level calibration measurement are higher spectral response, lower noise and higher absolute accuracy than any of the previous GERB instruments
- All of GERB 4 mirrors meet the advertised performance in the SW of the DENTON proprietary UV enhances silver coating, resulting in higher response <0.7μm
- Measured filtered response for all instruments very similar.
- Differences between the new detector measurements and the ones used for GERB 1-3 are in general within the (large) uncertainties placed on the GERB 1-3 detector data.
- Measurements still in analysis on the last remaining Honeywell detector with the new technique should inform on likely differences between different detectors in the same batch, and hence between GERB 4 and GERB 1-3 detectors.